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The Virginia Journal of Science

VOL. III

MAY, 1942

No. 5

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Published by The Virginia Academy of Science
Monthly, except June, July, August and September
at
Lexington, Virginia.



The Virginia Journal of Science

Official journal
of the
VIRGINIA ACADEMY OF SCIENCE

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Entered as second-class matter February 20, 1940, at the post office at Lexington, Virginia, under the Act of March 3, 1879. Subscription—\$1.00 per volume to members of the Virginia Academy of Science; \$2.00 per volume to others. Published at Lexington, Virginia.

Emile Duvall

The Virginia Journal of Science

VOL. III

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Histological and Anatomical Changes Induced by Indoleacetic Acid in Rooting Cuttings of *Pinus Strobus* L.¹

ALBERT L. DELISLE

In a recent paper on the rooting behavior of various "difficult" plants from cuttings (Thimann and Delisle, 1939), it was shown that the age of the tree from which the cuttings were taken, determines, in large measure, the rooting ability of these cuttings. This condition is especially true in *Pinus Strobus* L., cuttings of which, when taken from young trees and treated with indoleacetic acid, root readily, but not at all when taken from old trees and treated in the same manner (cf. Snow, 1940). This difference in rooting ability between cuttings of the same age, but from trees of different ages, may be due to either physiological or anatomical differences, or to both.

Since many of our experiments have been conducted largely on conifers and especially with white pine, and, inasmuch as it has been found that auxin readily stimulates cuttings of white pine to root, it was felt desirable to conduct an anatomical investigation of the histological changes accompanying rooting in this plant.

The origin and development of adventitious roots has already been studied in many species of plants. In general, it has been found that the roots may be initiated in various tissues, either from cells which have remained meristematic or from cells which have become so, after having reached maturity. Since morphological and anatomical features appear to be important in the rooting of cuttings, a study of histological changes induced by auxin, and its effect on the initiation of new meristems, should prove of fundamental importance in practices involving vegetative propagation.

Much work has been done on the gross changes induced on plants by applications of growth substances, but few studies have been made primarily with the particular tissues concerned. By and large, adventitious roots (Eames and MacDaniels, 1929) develop by the formation of apical root meristems in the stem pericycle when present or in the secondary phloem when the pericycle is no longer active. In a comprehensive study of vegetative propagation from the standpoint of plant anatomy, Priestley and Swingle (1929) indicated "the pericyclic origin of roots

¹Joint contribution from the Biological Laboratories, Harvard University; and the Virginia Fisheries Laboratory and Department of Biology, College of William and Mary (No. 11).

Grateful acknowledgement is made to the Virginia Academy of Science for a Research Grant and other assistance in making this work possible.

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on young stems and their origin in the neighborhood of the cambium on older stems". In both cases, they arise in close association with the rays and involve more than one layer of cells. In *Coleus* cuttings (Carlson, 1929), the adventitious roots arise in the pericycle between the fibrovascular bundles. In the rose, however, (Carlson, 1933) the adventitious roots arise from the unusual development of parenchymatous secondary phloem, with occasional roots arising in a leaf trace. In flax seedlings (Crooks, 1933), on the contrary, adventitious roots often involve pericycle, phloem, and pith.

There is an increasing array of evidence showing that other tissues, such as the cambium, ray tissues, etc., are also involved in the production of adventive roots. In *Iresine*, Harrison (1937) found that neither the cambium nor the endodermis was greatly stimulated. In this same material, ray, phloem, and pericycle, and even pith tissue, gave rise to lateral roots. Dorn (1938) showed that the cambium is not the only tissue giving rise to roots. Snow (1935) and Söding (1937) have found, however, that treatment with indoleacetic acid greatly stimulates the cambium of a variety of plants.

In the bean plant (Kraus, Brown and Hamner, 1936), the histogens of adventitious roots seem to arise mainly in cells derived from the rays. In this plant, the endodermis and the parenchyma of both primary and secondary phloem contribute greatly to the outer tissues of the apical crown of adventitious roots. In the presence of indoleacetic acid in the bean, the cells of the cortical parenchyma, of the endodermis, of the cambium, and of the pith become meristematic and proliferate actively, in some cases maturing as vascular strands.

In *Lilium* (Beal, 1938), the adventitious roots differentiate by repeated divisions from meristematic cells in the fundamental parenchyma, lateral and centrifugal to the vascular bundles. In *Mirabilis* (Hamner, 1938), however, the roots which penetrated the cortex and epidermis were differentiated from derivatives of the pericycle or from tissue derived from both pericycle and interfascicular parenchyma or cambium.

In *Mirabilis* it was also found that, as a result of application of indoleacetic acid, the cells of the endodermis showed considerable response. In this same plant, at first the pith responded slowly to treatment, then more rapidly, proliferating internal roots or strands of vascular tissue in the vicinity of the vascular bundles.

In *Lycopodium lucidulum*, (Delisle, unpublished), there is evidence that the new roots emerge from the pericycle. Adventitious roots in *Thuja occidentalis* (Bannan, 1941) originating in the outer tissues are continuous with xylem rays of parenchyma cells only. Roots in *Chlorophytum elatum*, (Naylor and Sperry, 1938), arise adventitiously from thin-walled parenchyma close to the vascular system.

Studying the effect of growth substances, Swingle (1940)

pointed out that growth substances stimulate markedly the cambium to growth and division, but do not cause the cambial derivatives to differentiate into vessels, fibers, etc., a condition dependent on other factors. In anatomical studies of root and shoot primordia in apple root cuttings (Siegler and Bowman, 1939), it was reported that adventive root and shoot anlagen arise in tissues with much secondary growth, and "that adventive root primordia originate in the region of the vascular cambium, either in ray parenchyma or in near-derivatives of cambial cells not associated with rays". This is in close agreement with the findings of Priestley and Swingle (1929).

Materials and Methods.—Cuttings were made from 4 year-old white pine trees.² They were taken from both lateral and terminal branches in the fall of 1938 and represented the current year's growth, and, in some cases, portions of the preceding year's growth. They were of rather uniform size, ranging from 3 to 5 inches in length, and cut below the junction of two successive years' growth. After treatment with aqueous solutions of indoleacetic acid (100, 200, 400mg/L.) for 24 hours, the cuttings were planted in a 2 to 1 sand-peat mixture. After 5 weeks, the representative cuttings were collected and fixed in Allen and Wilson's modification of Bouin's solution for 24 hours. After softening in hydrofluoric acid, the material was run up in celloidin (Wetmore, 1932), sectioned and mounted serially.

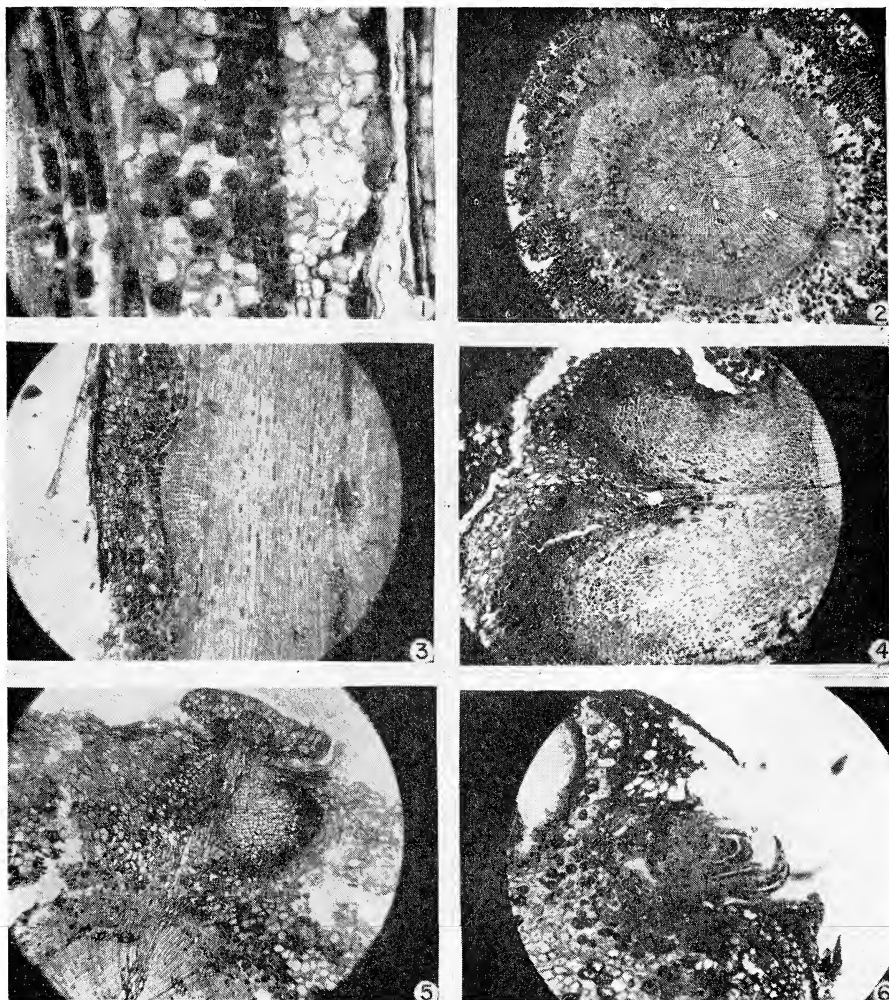
Morphology.—In cuttings from 4-year old trees following treatment with auxin, after two or three weeks, there is a marked swelling of the basal ends with production of a considerable amount of callus tissue. In optimal auxin concentration (Thimann and Delisle, 1939 and 1942), after four and one-half to five weeks, roots begin to appear at the base of the cuttings. In cuttings of corresponding age from older trees, there is no observable difference or even swelling at this time, or subsequently. The former root easily on treatment with auxin; the latter, practically not at all. With the exception of an occasional plant, there is very little rooting without auxin. Cuttings from one or two-year old white pines, however, root readily even without auxin treatment.

A curious part-reversal of the age phenomenon is found in the rooting of brachyblasts or short shoots of young and old pines. Treated brachyblasts from the latter may root up to 3% to 5% and those from young pines up to 74% (Delisle and Thimann, 1942). Due to their inability to produce terminal buds, rooted brachyblasts eventually die. However, if a terminal bud develops, the rooted brachyblast behaves as a normal cutting and survives.³

²These were obtained from the Quabbin dam Watershed at Enfield, by courtesy of the Massachusetts State Department of Conservation. Sections were cut 15 micra in thickness, and stained in safranin and Heidenhain's iron haematoxylin. Photomicrographs were made on Eastman Panchromatic film using a yellow corning filter.

³It was noted that approximately 2 to 4% of vigorous auxin rooted cuttings produce some brachyblasts with terminal buds. Two of four of these brachyblasts, excised from the plant and treated with auxin, rooted readily, and survived to grow later into normal plants.

Anatomy—A study of transverse sections of cuttings from young and old trees of corresponding age, respectively, show some anatomical differences. It was noted, for example, that the living cells of the pith, cortex, and rays retain their protoplasm for a longer time (over two years in our material) in the cuttings from young trees than in corresponding cuttings from old trees. In the latter, the cortex cells soon degenerate and become crushed. After the first annual increment, the pith cells lose



1. Longisection through a 4-year white pine stem showing nature of periderm-like layer in center of cortex. Note binucleate condition of several cells. 2. Transverse section through same. Note extensive activity of cambium. 3. Longitudinal view of young root anlage, shown in 2. 4. Enlarged view of two root primordia penetrating the cortex. 5. Adventitious roots arising in cortical cells bordering leaf trace. 6. Adventitious bud in outer cortex. All auxin treated.

their contents and die. Further, the cortex of treated cuttings from young trees soon becomes meristematic, whereas, that of corresponding cuttings from old trees remains unchanged or degenerates.

One of the first noticeable changes in response to auxin takes place in the outer cortex. The subepidermal layer of this tissue seems to divide and form a periderm, including an extensive layer of dark staining cork cells, a cork cambium, and, sometimes, a very slight phelloderm. In conjunction with the development of the periderm, there is very extensive activation of the cortical and pericyclic cells. As shown in Fig. 1, practically all these cells initiate mitotic division, soon obliterating the cortical canals by pressure of the dividing adjacent cells. Frequently, the dividing cortical cells fail to produce a cell plate between the daughter cells at mitosis, resulting in a binuclear condition of the cells (see Fig. 1). At the basal end of the cutting, in optimal auxin concentration, the wood cambium becomes very active, producing much secondary tissue (Fig. 2), both in the phloem and in the xylem, which consists of a large amount of parenchyma. Fig. 3 is a longisection of a young root anlage, showing the localized activation of the cambium to produce much undifferentiated parenchyma. This will later produce an adventitious root.

Cambial activity does not proceed equally throughout the circumference of the cutting. At certain places, the cambium divides more actively, producing cushions of meristematic cells, and virtually no wood or phloem. These cells go on dividing and soon produce the root anlage, which, by further division, pushes its way through the phloem (see Fig. 4), cortex, and periderm. These cambial cushions are generally associated with the rays and the leaf traces. They are usually found adjacent to a leaf trace and at the end of a congerie of rays. Ideally, a section with five leaf traces may even show ten root anlagen, although this number of roots does not usually develop.

The cells of the pith do not become activated in any way. There are no cell divisions or undue enlargements in this tissue.

In a few cases, adventitious roots have been observed to arise from the leaf trace parenchyma (see Fig. 5) in the region of the callus, and at a point anterior to the passage of the leaf trace into the leaf base. In Fig. 5, there are two root primordia of unequal size, flanking the double leaf trace, one on either side. Fig. 6 shows a longitudinal section of an adventitious bud arising from cells in the cortex.

A longitudinal section through the center of the stem shows the nature of the secondary tissue. The new xylem cells are provided with close, crowded pit pairs (see Fig. 1), somewhat resembling araucarian pitting and are frequently found on both the radial and tangential walls of the same tracheids in the new wood, originating after auxin treatment.

SUMMARY

1. Transverse and longitudinal sections of four-year old white pine cuttings treated with indoleacetic acid were made.
2. White pine brachyblasts from both young and old trees were rooted with auxin. These rooted when detached from the cuttings, and survived only when a terminal bud was present or was induced to develop on them.
3. The first noticeable anatomical change, following auxin treatment, is in the outer cortex, where a periderm-like layer is initiated.
4. At the basal end of the cutting, the wood cambium becomes very active, producing much parenchymatous secondary tissue.
5. Cambial activity is greater at certain places, producing cushions of meristematic cells, which later become the root anlagen, and which seem to be associated, by position, with the rays and the leaf traces.
6. Pith cells do not become active at all.
7. Adventitious roots have been seen to arise also from the parenchyma of the leaf trace.
8. Close crowded pit pairs on both the tangential and radial walls of the new xylem cells are produced following auxin treatment.

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Lamium amplexicaule L., forma clandestinum (Reichenb.) G. Beck.

H. A. ALLARD

Henbit, *Lamium amplexicaule* L., is one of the most common and widespread weeds in waste grounds everywhere. It is an Old-World plant, with an aggressiveness which has made it quite at home wherever it has been introduced.

Tests by the writer have shown that it is a day-neutral plant, and this behavior enables it to grow and to reproduce wherever temperatures are favorable for its survival and growth, whether the days are long or short. Its ability to withstand cold and to grow at low temperatures, together with its indifference to length of day, explains its aggressiveness. As a matter of fact, it appears to withstand the low temperatures of the winter in many sections of the South better than the hot summer temperatures.

Henbit is an interesting plant in other respects. It has the habit of producing more than one form of blossom, depending upon the conditions under which it grows. The normal, fully developed blossom with expanded corolla is the form of flower most commonly observed. This is usually called into expression by the long days and warm temperatures of the summer season.

During the cooler season of the year, there is a noticeable change in the flowering behavior of the plant. In autumn and winter, or until warm weather prevails in late spring, the open or chasmogamous blossom is suppressed, being replaced by bud-like cleistogamous blossoms. Where the reduction in size has been extreme, these may be very tiny and inconspicuous; yet they are characterized by a high fertility, and are therefore self-fertile. Although the open summer blossoms are visited by various pollinating insects, so that crossing within the population may readily occur, the tiny, closed winter blossoms exclude any chances of pollen transfer by insects, even if pollinating insects were active at this season.

In response to the prevailing low temperatures of the winter-time and a length of day which falls below 12 hours from October to late March, 100% of the blossoms may be of the cleistogamic sort. In summer, on the other hand, when high temperatures and long days prevail, the fully expanded, open blossoms alone are produced. The period of transition, especially in early summer, is characterized by both cleistogamic and open, fully developed flowers.

Plants with the minute, cleistogamous form of blossom, naturally have not been as extensively collected and preserved in herbaria as those with the more normal open blossoms, so that *clandestinum* might appear to be a rather rare and unusual form in a locality from a study of herbarium material. This is quite contrary to fact, and any predominance of one or the other in an herbarium would depend upon the season when most collecting has been made, which naturally is in summer-time.

M. L. Fernald, in his interesting botanical notes "Another Century of Additions to the Flora of Virginia" (*Rhodora* 43: (516), 1941, 635-657), has listed this forma *clandestinum* as occurring in Southeast Virginia, whereas other collections from this area, it is stated, exhibit the fully developed, showy corolla. This form, however, represents the prevailing winter behavior of this plant everywhere.

In tests at Arlington, Virginia, where plants of *Lamium amplexicaule* from germination experienced constant length of day of 10 and 12 hours, the very tiny plants, scarcely three inches in height, flowered abundantly. These, however, produced only cleistogamic blossoms, whereas plants experiencing the full day produced open, showy blossoms.

It is obvious, then, that the botanist, listing forma *clandestinum* as an element of the flora, should bear in mind that it represents a response to certain conditions of the habitat to which this plant is particularly sensitive, rather than something with a genetic constancy.

WASHINGTON, D. C.

A Genetic Study of Family Lines in Virginia

E. S. CRAIGHILL HANDY AND ELIZABETH G. HANDY

The usual procedure in genetic study involves the tracing of one or several heritable traits or characters through successive matings in descending generations. In the standard form of chart employed to record the spread of individuals from successive matings, squares represent males and circles females, the symbols for man and wife being joined by a horizontal line, from which a vertical line descends to a horizontal bracket along which are plotted the squares and circles representing offspring. Where the incidence of a single character is represented, it is shown by blacking out the squares or circles where the trait appears. A good illustration of such a chart is Fig. 6 in Dr. Lawrence H. Snyder's "Principles of Heredity" (1940), depicting the incidence of polydactylism, or six fingers on the hands, in four generations of a family.

By marking the squares and circles representing respectively male and female on such a chart it is possible to plot the occurrence of a number of characters or traits. The International Committee of Eugenics has standardized the use of letters upon or beside the squares or circles to record traits which concern eugenics. They also indicate the use of black and white cross-hatching, dots, blocking out of segments, etc., as a means of plotting the distribution of a variety of characters. How this works out in a complicated study of inheritance may well be seen in the charts appearing in Dr. C. B. Davenport's "Naval Officers, their Heredity and Development" (1919). In this study, by means of different markings, some seventeen different characteristics are represented.

These references to the standardized forms of genetic chart with which every biologist is familiar are made simply by way of indicating that the wholly different type of chart which we are working with is in no way intended to be a substitute for or an improvement on the accepted mode of representation. What we are attempting requires the tabulation not only of a great variety of traits, but also of numerous factors social and cultural, of heritage and environment. Furthermore, our problem becomes doubly complicated, as compared with simple research in human genetics, by reason of the fact that we seek, in so far as information is available, to define the total potential field of inheritance and heritage by making the Propositus a genetic focus in a genealogical setting reaching both backwards and forwards.

The Propositus is in the center of our sheet. Above are radiating zones upon which can be written the names of the ascending generations of ancestors for six generations. This upper half of the sheet represents the total potential field of genes focusing in the Propositus. Below the Propositus is entered the

name of the person married. The middle portion of the lower half of the sheet has, arranged in a logical pattern, brackets for Propositus' children, whom they marry, and their children (the Propositus' grandchildren); for brothers and sisters of the Propositus, their marriages and their children (nephews and nieces of the Propositus); for uncles and aunts of the Propositus on father's and mother's sides respectively, their marriages and the children of these unions (the cousins of the Propositus). This genealogical arrangement we have found after experimenting with various forms to be the most convenient and least complicated for the entry of a large number of symbols.

The left hand side of the lower half of the chart is a panel representing cultural interests and activities of the Propositus. The list of these is as follows: Art, writing, language, reading and study, public speaking, teaching and preaching, ethics and worship, social work and science, fraternal organizations and clubs, politics, law, clerical work, commerce, finance, production and provision, promotion and speculation, management and planning, operation, command, naval service, military service, civil service, travel, mechanics, mathematics, engineering, craft-work, physical science, natural science, medicine, land culture, breeding, sport. Each activity is represented by a simple pictographic symbol. At the bottom of this panel is a list of conditioning cultural factors affecting the childhood of the Propositus, also represented by pictographic symbols. The checking of symbols in this panel is based upon interview, life history, biography and other documentary evidence.

The right hand side of the lower half of the chart defines (1) the Ethnic Type of the Propositus by means of measurements, observations and photographs in accordance with established techniques of racial anthropology (in conformity with procedures and classifications of Drs. E. A. Hooton and Carleton Coon¹), and (2) the Constitutional Type (applying the procedure and definitions of Dr. William H. Sheldon²). A second order of symbols (consisting of letters and numbers) referring to this panel represents the fundamental ethnic and constitutional traits of the Propositus, and, in addition, significant clinical factors recorded in the life history, from trustworthy medical examination, or records.

This Comprehensive Chart, as we call it, is still in an experimental phase. It is not as complicated as the above description implies: in fact it is far easier to use than to describe. It is the best solution for the problem of establishing a systematic technique and procedure that will enable us to tabulate on a single sheet the whole character of the individual with respect to ethnic type, constitutional type, psychic type, physical and environmental conditioning factors, and activities and interests as indicative of culture, heritage and ability, and at the same

¹Carleton S. Coon, "The Races of Europe, 1939. (Macmillan).

² W. H. Sheldon, *The Varieties of Human Physique*, 1940. (Harper).

time to arrange this tabulation in such a way as to record the whole in terms of inheritance and genetic distribution. Over fifty symbols represent all the elements defined. Those symbols which characterize the Propositus are entered at the center of the chart over his or her name. Thereafter follows the complicated, but we find not impossible, procedure of locating the occurrence of the same traits in recent ancestors, close senior relatives, siblings, cousins and immediate descendants, the symbols being entered in red over the names on the genealogical chart. Some of these charts, we believe, will gradually become genetic maps, using the word genetic here in a broad sense. The work will be slow, but as charts of interrelated lines are worked on, it will be cumulative. We are assured that some valuable evidences will appear in time, to be studied in detail. Only with respect to the living, of course, will we have full information.

It is obvious that it would be impractical to utilize the standard form of genetic chart for making the kind of records we require: by the time one has gone two generations above the Propositus a mesh of interlocking lines begins to appear. It is, in fact, impossible, to represent the expanding fan of ancestral background by means of the standard genetic chart.³ These charts with which we are working experimentally are simply elaborate forms for tabulating complicated data concisely. The entries are backed by documented evidence. In time, we believe, genetic charts of the usual type, relating to specific characters, may be worked out from our Comprehensive Charts; and that there will be enough data for statistical checking and analysis. A basic conception in our program is the gradual building up of archives of these charts in key localities, relating to carefully chosen interrelated families. These archives may ultimately be shared for study with authenticated researchers engaged in various types of investigation: medical, genetic, anthropological, sociological, historical and biographical. Our plan is gradually to build up groups of charts covering interrelated families of the various Virginian ethnic strains in the main geographical sections of the State: Tidewater, Piedmont, Valley, Highland and Southwest.

Virginia is a field that offers unique advantages for this research by reason of her Colonial and subsequent history, and her people's interest in family history, genealogy and biography. Certainly there is no better region in America for this particular type of investigation.

Public, institutional and private archives relating to family and persons contain a great variety of materials bearing on the points relating to individuals of past generations who may ap-

³Recently we have had opportunity to submit our procedure to Dr. Lawrence H. Snyder, Professor of Genetics in the Medical School of Ohio State University, for his criticism and comment. He remarked that our method of plotting the ancestral field introduces something that has had little place in biological genetics, namely the genealogical perspective. He seemed also impressed with the value of our procedure, if carefully handled, in recording and defining environmental factors.

pear on our charts. Families will be studied concerning which such material is available.

Ethnically, the early settlement of Virginia was definitely regional. English stock predominated throughout Tidewater, the Southside and lower James River Valley. French Huguenot settlement was concentrated in certain localities of this same general region, particularly in what are now Nansemond, Powhatan and Goochland counties. Scotch and Scotch-Irish, immigrating through Virginia and Maryland ports and coming also through Pennsylvania, were attracted to the upper Shenandoah Valley and passed beyond to the highland counties of the west and southwest sections. In the Shenandoah they were followed by America's most skilled farming stock, Protestant Germans from the Palatinate Rhineland (inaccurately termed in Pennsylvania "the Pennsylvania Dutch"). Other German settlers came in considerable numbers both to the Tidewater and Piedmont regions. There are, we are told, fairly pure Welsh strains in some mining localities.

While these strains, derived from racially mixed national ethnic groups in the colonial period, have to a considerable degree intermingled in the subsequent phases of pioneering, and in the flux of population accompanying and following the Revolutionary and Civil Wars, nevertheless the physical traits of original types (English, French, Scotch, Irish, German and Welsh), and distinctive cultural character and traditions of these stocks persist definitely and clearly in particular localities and certain families. This may be attributed to three factors: (1) some branches of many families simply "stay put" in the section found congenial to their forebears; (2) congeniality in marriage is found with persons of the same locality, church, and cultural and social heritage; and finally, (3) immigration subsequent to colonial times has been very slight in rural sections and small communities.⁴

We have been working in an exploratory way for a year now both on historical and living characters in a few families. In the present tentative and experimental stage of the research we feel that it would serve no good purpose to name the families, characters or persons studied. There are no secrets or "undercover sleuthing" in our procedures, but, frankly, we are certain that at present publicity as to this particular aspect of our investigation might prejudice some people who later will understand clearly that we are not hunting skeletons in private closets, lethal genes, or dismal degeneracy. In this connection let us say that what we are concerned with is not pathology, physical or social, but fundamentally with discovering what constitutes and produces normal sound endowment, character and achievement; what are the handicaps that reduce such character and achievement and what are the favorable factors that enhance them; what changes have been wrought in types by environmental condi-

⁴In appraising the ethnic phase of our field we have found guidance and inspiration in Dr. R. Bennett Bean's "The Peopling of Virginia", (Chapman and Grimes, Boston).

tions peculiar to different sections of the State; what correlations there may be between ethnic or constitutional type and endowment, career and adaptability; and finally, how traits and character are transmitted, conditioned, lost, or produced. Wherein and why are all Virginians, of whatever breed, so Virginian and so American today? Wherein and why are some, retaining relative ethnic purity from colonial times, so strongly marked still, physically, psychologically and culturally as derivatives of English, Scotch, Irish, French and German prototypes? What types have best thrived in the Tidewater, and what types in the Valley or the mountains; and why? There will be in time on our charts interesting evidence on innumerable questions, opening the way to more detailed investigation of problems of fundamental significance in human affairs.

Human genetics is necessarily a long-range enterprise. One cannot experiment with human breeding as with animals and plants. Records covering a vast span of years must be accumulated and then appraised with meticulous and comprehensive care. No satisfactory measurement or appraisal of environmental factors affecting the situation has ever been achieved—the simple fact being that biologists, failing to cope with this problem, simply leave it out. This is serious in human genetics, for environmental factors undoubtedly increasingly outweigh simple genetic determinants the more man advances beyond the mere creature stage of evolution to become person, endowed with the attributes that differentiate man from animal in the natural world, namely with character, social sense and culture. In the long-range prosecution of a fully rounded study of human inheritance, systematic records over many years are the first essential. Our modest hope is simply to make a beginning in this field.

It is with pleasure that we acknowledge with heartfelt appreciation both the cordial encouragement and generous material aid that the Virginia Academy of Science has given us at the inception of this study. The Research Committee in 1941 did us the greatest favor that can be rendered a new and difficult project, giving us understanding, interest, and recognition. In particular we want to thank at Richmond Dean Rudd, Drs. E. C. L. Miller, Apperly and Main. At Charlottesville Dean Lewis, Drs. Bean, Geldard and O. E. White have given us every “aid and comfort”; and in the Alderman Library Mr. Clemons and Mr. Berkeley have by their cordiality and interest made that beautiful library, to use a phrase from horse and buggy days, “our main hitching post”. Last, but not least, we thank Dr. E. G. Swem at William and Mary for his warm interest and generous help. Without his monumental “Virginia Historical Index” we now know, after this year’s study, that the genealogical phase of the work would have become an insuperable obstacle to rapid progress.

In the planning of the project and consideration of technical details we wish, finally, to acknowledge the cordial interest and encouragement of Drs. E. A. Hooton and William H. Sheldon of Harvard.

OAKTON,
FAIRFAX COUNTY, VA.

An Early Virginia Scientist's Botanical Observations in the South

RICHARD BEALE DAVIS

In the manuscript division of the Duke University Library there is a wallet-notebook kept by a young Virginia botanist, Francis Walker Gilmer,¹ between 1815 and 1820. The book contains a Cherokee-English vocabulary, Gilmer family data, copyings of famous English poems, other odds and ends, and most interesting, a series of botanical jottings. These names of flora were gathered from observations from Bedford, Pennsylvania, to lower Georgia and South Carolina.

Gilmer, the young friend of Thomas Jefferson who was later sent to Europe to gather the first faculty for the University of Virginia, had undoubtedly developed some of his scientific enthusiasm from Jefferson himself. With Jefferson he had visited the Peaks of Otter and had made observations upon them, and at Jefferson's Poplar Forest estate in Bedford County he had made records of observations in this notebook. In 1815, in company with the famous Portuguese scientist the Abbe Correa,² Gilmer had visited the Cherokee country, Athens and Augusta in Georgia, and Charleston and Columbia in South Carolina. In 1819 he again went to Georgia with Mr. John Patterson, a Richmond merchant. On both trips he recorded many plants unfamiliar to him. On summer excursions to Pennsylvania and "lower Virginia" he made a few more scattered observations.

These are an amateur's notes on botanical specimens which interested him. From the professional scientist's point of view, they may be valuable as early recordings of certain plants. From the general reader's point of view, they afford another evidence of the varied intellectual interests of Jefferson and his friends in the first quarter of the nineteenth century.

GILMER'S NOTEBOOK OBSERVATIONS

[These items appear on consecutive pages in the notebook. Evidently, however, they were written down at various times rather haphazardly. Items or lists taking more than one page appear to have been written in reverse order; that is, from back to front of the notebook. The sheets are badly damaged, making items at the top and bottom of pages completely indecipherable.

The observations were first made in pencil and later traced in ink. Sometimes changes were made in the tracing, and some of the pencil notations were not traced. An attempt has been made here to include all of the original notations which can be deciphered.

I am indebted to Professor Henry C. Davis of the University of South Carolina for assistance in deciphering the notations, and to Professor Paul

¹Cf. R. B. Davis, *Francis Walker Gilmer: Life and Learning in Jefferson's Virginia*, (Richmond, 1939); "Forgotten Scientists in Old Virginia," *Virginia Magazine of History and Biography*, April 1938: "Literary Tastes in Virginia before Poe," *William and Mary Quarterly Magazine*, January 1939.

²Cf. *Encyclopaedia Britannica*, 11th ed., for biographical article, or R. B. Davis, "Forgotten Scientists in Georgia and South Carolina," in *Georgia Historical Quarterly* (probably second quarter, 1943).

J. Philson of the University of South Carolina for the botanical comments included in parentheses after all items which could be interpreted.

The short single and double lines between items are Gilmer's. The brackets are his also. The parentheses are Professor Philson's explanations or mine. Gilmer did not italicize his items. "Mchx." refers to Michaux and "L." to Linnaeus, famous botanical observers. Other references are similar.]

Georgia 1819. with Jⁿ Patterson
Plants

Podallyria mollis (known today as *Thermopsis mollis* [Michx.] M.A. Curtis— *Alleghany thermoposis*.)

Dalibarda Fragariodes (= *Waldsteinia fragarioides*— Barren or Dry Strawberry.)

a curious plant 18 m. S. Washington Georgia
Dacapdria monog. cal. unic. 5 dent

Cor. monop
solitario (inserted)
foliis pinnatis. hab. cassice. flor.
negro — pur.

Plant supposed to be *Styrax* — (Probably was. Two species. One very common— *Styrax Americana* L.)

—monad. Poland: rather Poly. monog.

Bractia bif : Cal : unic. 5 dent :

Cor : 5 petal : pet : marg. crenatis

Caps. 5 locularis. fol. petiol (?)

acumenatis — ceoites (?) dentatis.

====

The plants in Jusseius Genera which have been called after Botanists of various nations stand thus .

French 108. English 78. Germans 127. Italians 51.

Swedes 46. Spanish 22. Portuguese 3. Poles. 1.

(end of notebook page "1")

(. . . . ?) p orchis

Tapioca iatrophia

Myristica nutmeg (*Myristica*)

Sago Cycas

gum arabic mimosa nilotica

(end of page "2." The rest of this page is written from the other end as top. It is concerned with the Gilmer genealogy)

Hieracium Gronovii (= *Hieracium Gronovii* L. — Hairy Hawkweed.)

Uratica pumila (= *Pilea pumila* L. A. Gray— Clearweed, Coalweed.)

Lysimachia ciliata (= *Steironema ciliatum* L. Raf. Fringed Loosestrife.)

Queria canadensis — Anychia of Michaux (= *Anychia canadensis* L. B.S.P. Slender Forked Chickweed.)

Bidens [quae] Chrysanthemoides (= *Bidens laevis* L. B.S.P. Brook Sunflower.)

Mintha virides [common kind } (= *Mentha spicata* L. Spearmint
borealis larger, verticillata } or common mint

Briza Eragrostis (This species reaches its Southern limit in Pennsylvania. Probably some species of the genus *Eragrostis* was seen.)

Isanthus Caeruleus (= *Isanthus brachiatus* L. B.S.P.— False pennyroyal.)

Broussonetia papyrifera [Mulberry of Otaheite] (= *Papyrius papyrifera* L. Kuntze. Paper Mulberry.)

====

The above plants were seen in the excursion with Mr. Correa from Sept^r to Nov^r. 1815.

=====
1816 Bedford Pennsylv (?) th July

Pyrola asarifolia (Michx. Correct. Liver-leaf Wintergreen.)
Rudbeckia Chrysomela

{ Michaux
{ puzzled us in Cherokee nation] (Several species of *Rudbeckia* are common, but no species *Chrysomela* is found in literature.)

1817 in lower Virginia

Limodorum (One species common— *Limodorum tuberosum* L. — Grass-pink or Calopogon.)

Chelidonium (= *Chelidonium majus* L. Only one species in Virginia.)

—The Glaucous aquatic so often seen without fructification, saw the ripe seeds. they grow on a long amentum. as large as peas. pulpy—with a corticle around them like an arum(?) but no clayx (?) when I saw them [Pothos]

Skrankeia uncinata (?) — sensitive plant (= *Leptoglottis uncinata*.)

Antharium orontium (Probably some species of *antirrhinum*.)

Glaucium seu *Chelidonium* (= *Glaucium Glaucium* L. Karst. Sea poppy.)

Ly (?) odorum *Tubirosum* (= *Limodorum tuberosum* L.

(end of page "3".)

Cocx (?) [beads.] (Probably is *Coix Lachryma-Jobi* L. Job's tears or Tear grass. Only one species.)

Atriplox (= *Atriplex*. Salt-bushes or Oraches.)

Lippia (Now changed to *Phyla*. Fog— or Frog-fruits. Several species.)

Croton (Three species are common in S. C. — *C. glandulosus* L., *C. capitatus* Michx., and *C. punctatus* Jacq. He evidently observed one of these three.)

Erihne (guess)

Zizyphus volubus (?blur) (= *Zizyphus Zizyphus* L. Karst.)

Gritum maritimum (?) [Samphire of the English] S(y?)s— (blur) fruit of mangifera] a herbaceous vine

Decumaria (blur?) vine (Only one species in the S.E. — *Decumaria barbara* L. Common names— Wood-vamp. Climbing Hydrangea. Cowitch-vine.)

Volhaniria (?)

Tragia (Correct. Could be several species.)

Plumbago (No native species.)

Cleome (Correct. Spider-flowers. Several species.) farnesian (?)

Saracenia varialaris (?) (= *Sarracenia minor* Wolt. Hooded pitcher-plant.)

Veratrum (Could be one of three species.)

Narthecium. [—(?) eae *cacuminum* Lutice (Probably *Triantha racemosa* Walt. Small.)

Nerium. oleander (= *Nerium Oleander* L. Oleander.)

Sparthinae [grass of the salt marshes. (= *Spartina*. Six species.)

====

in S. Carolina (*sic pos.*)

Charleston

Near Winchester

veronica verticillata (Several species, but none named *verticillata*.)

Verbena angustifolia (Michaux. Correct)

Samolus Varolandi (= *Samolus floribundus* H. B. K.)

Argemone Mexicana (L. Correct)

Hypopus nepclodes (?)

Myrosotes Virginica (= *Myosotis virginica* L. B.S.P. Forget-me-not.)

Geum (Correct)

Trichodium lasciflorum & *decumens* (?)

Iteadites Atropurpurea.

Clinopodium vulgare. (*C. vulgare* reaches its Southern limit in N. C. It is probable that Gilmer observed *C. georgianum* Harper.)

Pychrantemum in ceium (?) (Could this be *Pycnanthemum*?)

Lycopus Virginicus (Correct)

(end of page "4")

Podalyria perfoliata (—?) (Some species of *Baptisia*. False indigo.)

Itea [nov. spe:] (Gilmer believed he had discovered a new species. However, only one species is known in N. A.—*Itea virginica* L. Common in S. C. Common name—Virginia willow.)

Hudsonia cricoides

andromeda nitida (= *Neopieris nitida* Bartr. Britton. Fetter-bush.)

Gelsemium J., *Bignonia semper virens* L. (= *Gelsemium sempervirens* L. Ait. yellow Jasmine Yellow Jessamine or Carolina Jasmine.)

Ludwigia mollis (No such species of *Ludwigia*. Mistaken in his species, right in the genus.)

Chrysocoma nudata

(marked through) *magnolia* [*Gordonia*]

Glycine frutescens (= *Krauhia frutescens* L. Greene. American Wisteria.)

Mespilus arbutifolia (= *Aronia arbutifolia* L. Ell. Red Choke-Cherry.)

Baccharis halimifolia sessiflora (= *halimifolia* L. is the species common in S. C. The *sessiflora* is probably a notation denoting the sessile heads.)

Prinos glaber (= *Ilex glabra* L. A. Gray. Inkberry.)

Prenanthus virgatus (= *Nabalus virgatus* Michx. DC. Slender Rattlesnake-root.)

Liatris odoratissima [foliis radicalibus planta geneis] (= *Trilisa odoratissima* Walt. Cass. Carolina Vanilla)

paniculata (= *L. paniculata* Walt. Cass. Hairy Trisila.)

Xyris Jupicae (= *Xyris Caroliniana* Walt. Carolina Yellow-eyed grass.)

Cosmos bipinnatus [aff. *Coreopsis*. pro. examinationem] (= Probably a *Coreopsis*. May be an escaped cultivated form.)

Rhexia glabella (= *Rhexia Alifanus* Walt. Meadow-beauty.)

Coryza pyenostachya [black root fac. Gnaphalic caul. abit.] (?)

Scirpus spathaceus (= *Scirpus*, but no species *spathaceus*.)

Baccharis sessilifolia (No. *B. halimifolia* L. (See note ten items above.)

chamoerops acaulis

alisma plantago (= *Alisma subcordatum* (Raf. Amer. Water-plantain.)

Erythrina herbacea (L. Cardinal spear.)

Ulex europeus (= *Ulex europaeus* L. Prickly Broom.)

Stillingia sebifera [croton

| Charleston

sebiferum Lin

Salicornia ambigua (Michx. Woody Glasswort.)

micranthemum orbiculatum [aff. *Lessimachia* (?)] (= *Globifera umbrosa* Walt. J. F. Gmel.)

Zanthoxyl Tricarpium (= Can find no trace of such a species. He probably saw *Zanthoxylum Clava-Herculis* L. Prickly ash.)

Clypeola (= Probably *Alyssum alyssoides* L. Yellow Alyssum.)

Mangifera (*M. indica*, the only species, occurs in S. Florida. It is improbable that he saw it in Charleston.)

Illecebrum (?) *polygonoides* (Probably some species of Whitlow-wort, *Paronychia*.)

Cactus opuntia. [sat. *rubra*] (Most likely is *Opuntia Opuntia* L. Coult. Prickly pear.)

(end of page "5")

Cardiospermum halicacabum (L.) [capsula in flata] (Correct. Balloon vine.)
Dracocephalum (Correct. Lion's heart. Several species.)
Isatis tinctoria [woad.] (?)
Crotalaria sagittalis (L.) [partridge pea] Hitowee (Correct. Rattle-box.)
Croetaegus Spathulata [Georgia] (= *Crataegus spathulata* Michx. Small-fruited Haw.)
 punctata (= *Crataegus punctata* Jacq. Dotted Haw.)
Callicarpa americana (L.) (French Mulberry.)
Vitis (+) *arborea* Lin : [ampelopsis bifinnata michaux (= *Ampelopsis arborea* L. Rusby. Pinnate-leaved Ampelopsis.)
Cantua coronopifolia [Wild . . *Ipomaea rubra* Lin. *Oconee* [ipomopsis elegans Mich] (= *Gilia rubra* L. Heller.)

(The following, to end of page "6" is enclosed on Gilmer's notes by a bracket marked "Augusta.")

Galardia lanceolata (Michx.) [Syr. Pol. Frust] (Correct).
Scorzonera pinnatifida [Sgr. (?) aequal] (?).
Thymus Carolianus (No such species. May be *Thymus Serphyllum* L. Creeping Thyme.)
Galactia mollis. [quae] [Diad. dec. (= *Galactia volubilis* L. Britton. Downy Milk Pea.)
Chrysocoma capillacea (Undoubtedly a species of the genus *Euthamia*. There is no record of such a species.)
Tillandsia usneoides [long moss of Carolina (= *Dendropogon usneoides* L. Raf. Long- or Florida-Moss.)
Quercus cinerea (= *Q. cinerea* Michx. Ell. Cottony Golden Aster.)
Pentapetes (?)
Lagerströemia (One species—*L. indica* L. Crape-myrtle.)
Brunichia [sp. n.] (Only one species in N. A.; this discovered in 1788 by Banks. His was not a new species as he believed.)
St. aebelina [. quae.] (?)
Diordia Virginica (= *Diodia virginica* L. Large Buttonweed.)
Zornia tetraphylla [Hedys:^m aff] (sic) (= *Zornia bracteata* Walt. Gmel. *Zornia*.)
Hydropeltis (One species—*Brasenia Schreberi* Gmel. Water-shield.)
Polyprimum (One species—*Polyprimum procumbens* L. *Polyprimum*.)
Melananthera (Could this be *Melanthium*?)
 [Syng.
Stapelia [apocinae] [gigantic (sic) (Could this be *Staphylea*?)
Melanthium virginicum (L. Bunch flower.)
Eriocaulon (Correct. Several species. Hot-pins or Pipeworts.)
Scirpus (Many species. Bulrushes.)
Illacebrun [too minute for full examination] (Changed to *Paronychia*. Whitlows.)
Monniera cuncifolix (The genus now variously subdivided, but no genus with a species name similar to above.)
Hippioris vulgaris [aquat : fol vertic.] (= *Hippuris vulgaris* L. Bottle Bush.)
 (+) (sic) Gartner (?) has called the peculiar structure of the cotyledons of the vitis vitagros

(end of page "6")

Trem. . (illegible) *mesenterica* (?)
Symphoricarpos [Juss] *Lonicera* [linn.] *vulgaris* (= *S. Symphoricarpos* L. MacM. Coral-berry.)
Myriophyllum verticillatum [Naiades] (= *M. heterophyllum* Michx. is the species. *M. verticillatum* does not occur in the South-east.)
Buchnera americana (L. Correct. Bluehearts.)

Ilex Canadensis [sed quaere] (No *Ilex canadensis* is on record. There are many other species of *Ilex*, however, many common.)
Ageratum [quaere] (Correct)
Pancratium Maritimum (?)
Arundo Canadensis (= *Calamagrostis canadensis* Michx. Beauv. Blue-joint Grass.)
Staehelina [quaere] (Could this be *Staphylea*?)
Lycopodium complanatum [muscus. pulvis. (Correct.)

_____ | _____
 _____ | _____ inflammabiles Juss.]

Cherokee plants

(The following through "Vitis Labruscae," is surrounded by bracket marked "Hiwassee.")

Erianthus brevibarbis (Michx. Short-bearded Plume-grass.)
Adiantum pedatum [filix maidens hair] (= Maiden hair fern.)
Glycine dioica [rich weed-pea vine 7c] (= Either *Glycine Apias* L. or *Falcata comosa* L. Kuntze.)
Spiraea. Aruncus (Probably *Aruncus Aruncus* (L) Karst.)
andropogon avenaceum. macrourus (= *Andropogon glomeratus* Walt. B. S. P. Brown-grass.)
Solidago rigida (= Either *S. rigida* L. or *Oligoneuron grandiflorus* Raf. Small.)

Glycine apios (L. Ground-nut. Correct.)
 " *tomentosa* (= *Dolicholus tomentosus* L. Vail. Turning Dolicholus.)
 " *dioica* (?)

Hypericum fasciculatum. Lam. (Sand-weed.)
 angulosum (?)
 procumbens (?)

ocimum
Ulmus alata (Michx. Winged elm.)
 fulva (Michx. Slippery elm)
 americana (L.) [large common elm] (American-elm)

Vitis Labruscae [fox grape (= *V. Labrusca* L. Fox-grape.)
 rotundifolia [muscadin by Cherokees (= *Muscadinia rotundifolia.*
 Michx. Qua - lu - sce] Small Muscadine.)
Mespilus arbutifolia (= *Aronia arbutifolia* L. Red Choke-cherry.)
biburnum nudum: (= *Viburnum nudum* L. Large Withe-rod.)
Actaea spicata (In all probability this was *Actaea rubra* Ait. Willd.
 Red-bane-berry.)
Hydrosis (?) *Canadensis* (Probably *Hydrastis canadensis* L. Golden-rod.)
amorpha fruticosa. Erythrina (Correct. *Amorpha fruticosa* L. Indigo-bush.)
 [a vine which we could not make out, resembling
 Epidendrum] *Decumaria* — found it to be] (= *Decumaria barbara* L.
 Climbing Hydrangea. Only one species.)

(end of page "7")

(The following through "Psoralea melilotoides" is surrounded by bracket marked "Poplar Forest.")

Paco r (?)
Eupoatorium (= *Eupatorium*. There are dozens of species.)

Polymnia Tetragonatheca (second word faint) (Either *Polymnia Uvedalia* L. or *Tetragonotheca helianthoides* L.)
 Trichostema (Correct)
 Celosia [hab. Amaranthi] (= *Celosia nitida* Vohl. Occurs only in Florida and Texas.)
 Symphytum [hab codeorice (faint)] (= *Symphytum officinale* L. One species Healing-hub.)
 Staphylea trifolia [Rhamni] (Bladder-nut)
 Eleusine [[hab [digitara crab grass]] (= *Eleusine indica* L. Gaertn. Crab-grass.)
 Dolichus (= *Doilichus Lablab* L. Hyacinth bean.)
 (cancelled) [acrosticoides] (cancelled) (Gilmer must have seen the Christmas fern— *Polystichum acrostichoides*.)
 Clyperus [con— prepus
 Penstemon (Correct. Probably *B. hirsutus* (L.) Willd. This sp. most common.)
 Astragalus carolinianus (L. Correct. Carolina milk-vetch.)
 Alisma (Correct. Water-plantain. Probably *A. subcordatum* (Raf.) Amer. water-plantain.)
 Marchantia polymorpha [alga] (A liverwort, not an alga.)
 Peziza Crepularis [Fungus] (Peziza is correct, but can't check on the species.)
 Thopsia (= *Thapsium*.)
 Epilobium (Willow-herb. Several species.)
 Cnicus (?) Discolor (*Cirsium discolor* Muhl. Spreng. Field Thistle.)
 Glycina monoica (Name changed to *Falcata comosa* L. Kuntze. Wild-or Hog-peanut.)
 Kuhnia Eupatorides [Critonia michaux (= *Kuhnia eupatorioides* L. False-boneset.)
 Mikania scandens (Correct. Climbing hemp-vine)
 Elymus (Correct. Wild rye.)
 diatris macrostachyia [Virg a [squarrosa Tennessee (= *Lacinaria squarrosa* L. Hill. Blazing-star.
 Phyllanthus carolinensis (= *P. carolinensis* Walt.)
 (end of page "9")

UNIVERSITY OF SOUTH CAROLINA,
 COLUMBIA, S. C.

Cytological Relationships in the Euphorbiaceae

BRUCE A. PERRY

The Euphorbiaceae as a natural group of plants were first adequately delimited as a taxonomic unit by de Jussieu in 1789. Since this time many contributions have been made to the classification, phylogeny, morphology and anatomy of the group. Though the family has been known for many years, considerable differences of opinion still exist as to the number of genera and species involved. The family is closely related to the Geraniales by structure of the gynoecium, although greatly separated from other forms of the order by the amount of reduction in most of its flowers.

The Euphorbiaceae are recognized as one of the larger families of the dicotyledons. They are a relatively natural group, although showing many lines of evolution. The members of the family constitute an assemblage of herbs, shrubs and trees, sometimes cactus-like, and often with a milky juice. The spurgees include many plants of economic importance, yielding rubber (*Hevea*, spp.), edible roots and fruits (*Manihot*, etc.), valuable oils (*Aleurites*, *Ricinus*, etc.), and having valuable medicinal and poisonous properties (*Hura*, *Pedilanthus*, *Euphorbia*, *Phyllanthus*, etc.). The members of the family live in varied habitats, in many different areas of the tropical, sub-tropical and temperate world, and exhibit considerable diversity in growth types. Because of this great diversity of form and habitat, taxonomic affinities and phyletic relationships, the Euphorbiaceae are of special interest.

Chromosome cytology steadily becomes a more useful ally of taxonomy in an understanding of interspecific and intergeneric relationships in many plant groups. The possibility of showing taxonomically valuable cytological characters increases with a better understanding of the individuality and genetic continuity of the chromosomes. Comparative studies of chromosome number determinations, chromosome morphology, geographic distribution, and morphology of the plants involving about one hundred species of the Euphorbiaceae were made in order to determine the correlation existing between these phenomena and the phylogeny of the family.

Throughout all the genera studied there was found considerable uniformity in shape and size of the somatic chromosomes with the exception of the genus *Euphorbia*. The chromosome numbers ranged from $2n = 12$ in *Euphorbia dulcis* L. to $2n =$ ca. 200 in *E. ferox* Marlot and $2n =$ ca. 224 in *Acalypha Wilkesiana* var. *musiaca*. *Euphorbia ferox* is considered to be 20-ploid and the *Acalypha* is 32-ploid. Chromosome numbers of distantly related genera throughout the family indicate the presence of several series. A 7-, 8-, and 9-series is of common occurrence, with 6-, 10-, and 11-series being of secondary im-

portance. The presence of an 8-series in primitive genera, and in the most primitive species of these genera, indicates 8 as the primary basic number for the family. In the evolution of the family an ascending and a descending chromosome series has functioned with the establishment of secondary basic numbers of 6, 7, 9, 10, and 11.

The frequency of polyploidy in various families of angiosperms varies greatly. Polyploidy is particularly frequent in certain tribes and genera of the Ranunculaceae (Gregory 1941) and in the families Polygonaceae, Nymphaeaceae, Rosaceae, and Malvaceae (Stebbins 1940). On the other hand, there are a few families in which polyploidy is quite rare. Senn (1938) reported only 23 per cent. polyploidy in the Leguminosae. It was suggested by Müntzing (1936) that at least 50 per cent. of angiosperms are polyploids. In a previous study of polyploidy in *Euphorbia* (Perry 1943) it was found that about 40 per cent. of the species were polyploid. The frequency of polyploidy in the family, Euphorbiaceae, is approximately 50 per cent. Intraspecific polyploidy is apparently quite rare in this family. Except for *Euphorbia dentata* Michx. no case of intraspecific polyploidy has been observed during the present investigation. The study of chromosome numbers in the Euphorbiaceae suggest that aneuploidy and polyploidy have both been effective in speciation in the family.

Tischler (1935) presented data to show that among the dicotyledons in Schleswig-Holstein those with a northern distribution contained approximately twice as many polyploids as those with a southern distribution. It was also shown that polyploidy among dicotyledons of Iceland and the Faeroes Islands was considerably higher than for dicotyledons of Sicily. Hagerup (1932) concluded that extremes of heat, cold, or other unfavorable conditions could give rise to polyploids. Müntzing (1936) supported a theory that polyploids were more resistant to cold than were their related diploids. Anderson (1937) working with American species of *Tradescantia* and Hagerup (1938) with diploid and tetraploid *Orchis maculatus* also support this view. Senn (1938) in a study of the Leguminosae concluded that northern and wide distribution is not always associated with polyploidy. Clausen, Keck, and Hiesey (1940) in a study of the effect of varied environments on North American plants concluded that there was no support for the theory that polyploid complexes, forms with the higher chromosome numbers, occupy the more adverse environments. Bowden (1940) concluded that differences in the degree of winter hardiness of related species was not correlated with chromosome number differences.

In this connection it is interesting to analyze certain genera of the Euphorbiaceae. Eight genera have been selected for one of the following reasons: (1) The genus is more or less restricted to a particular region, e. g. *Aleurites* spp., *Hevea* spp.,

Manihot spp., and *Ricinus*. Or (2) the genus is rather widely distributed from temperate and sub-tropic regions into the tropical zone, e. g., *Acalypha* spp., *Croton* spp., *Euphorbia* spp., and *Mercurialis* spp.

Aleurites is a genus of 5-6 species distributed in the eastern tropics, southern Japan, southeastern China, S. Sea Islands, etc. Of the 4 species that have been studied cytologically three are diploid and one is tetraploid. The diploids occupy the more northern and colder region, while the tetraploid has a more southern and warmer distribution. The genus *Hevea* is confined to tropical America, especially throughout the Amazon region. All species studied are tetraploid. *Manihot* is distributed from Texas and Mexico to tropical America, especially Central America and Brazil. Chromosome numbers for 5 species and about 40 cultivated varieties have been reported, all are tetraploid. The genus *Ricinus* contains only one species, which is a diploid, from tropical Africa.

In the second group, containing the more widely distributed genera, we have *Acalypha* which is found primarily in tropical America and the Africa-Madagascar region. The diploid, *A. ostryaefolia* and the tetraploid, *A. virginica*, occupy the same relative geographic distribution. Of the 3 tropical species examined, one is tetraploid, one 16-ploid, and the other 32-ploid. The genus *Croton* is found in the tropics of both hemispheres with a few species in sub-tropic Asia and N. America. The 3 species which have been examined cytologically are all diploids from the more northern distribution of the genus in America. In *Euphorbia* we have two groups that are of especial interest here—those in the 7-series and those in the 10-series. In the 7-series diploids have been examined from northern Virginia, tetraploids from central Europe and western Asia to Greece and Asia Minor, and in the western hemisphere from Ontario to central Mexico and tropical America to Peru. Among the octoploids, one comes from the Caucasus, and 2 are found from Ontario and Minnesota to tropical America. The succulent representatives of the 10-series are distributed from South Africa and Madagascar to the Cape of Good Hope. In this group there are diploids, tetraploids, and higher polyploid forms. A 20-ploid species, *E. ferox*, comes from the Cape region. In *Mercurialis* the annual and diploid species occupy the same geographic distribution as do the 2 higher polyploid forms.

In these genera it will be seen that the relative distribution of diploids and polyploids varies greatly from genus to genus and from species to species. Some of the tropical genera are entirely diploid, others are entirely tetraploid, and still others have both diploid and tetraploid species. In general, the data on distribution, temperature, and polyploidy for the Euphorbiaceae support neither the concept that polyploids have a wider distribution than diploids, nor the concept that polyploids have

a more northern distribution than diploids. Instead the whole situation seems to be more complex, involving the origin of the species in question and its geographic relationship.

Müntzing (1936) tabulated the chromosome numbers of 582 species of European angiosperms belonging to 48 genera in which both annual and perennials occurred. It was found that the average chromosome number of the perennial species was not less than 59 per cent. higher than that of the annual species. This correlation between high chromosome number and the perennial condition was considered to be statistically significant. He concluded from this fact that "A large number of perennial species must have originated from annual types with lower chromosome numbers." Senn (1938) made a similar study of the relation between chromosome number and life duration in the Leguminosae. He concluded that the data from the Leguminosae support Müntzing. Senn stated, further, that "the data also show that woody legumes may have originated from herbaceous legumes with lower chromosome numbers.

The data from the chromosome number lists of the Euphorbiaceae have been compiled and averages prepared to show the mean chromosome number of annual and perennial species in the family. The following results were obtained:

Average $2n$ chromosome number of annual species 23.3

Average $2n$ chromosome number of perennial species 37.1.

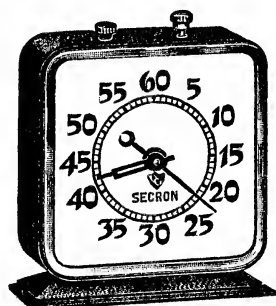
The difference between perennial and annual species is 13.8, or an approximate increase of 60 per cent. This difference in average chromosome number indicates that there is a relatively low percentage of polyploid species among annuals as contrasted with perennial species. Furthermore it would seem that the direction of evolution in the family has been from the annual to the perennial condition, as has been found for the Crassulaceae (Baldwin 1940), the Leguminosae (Senn. 1938) and the Ranunculaceae (Gregory 1941).

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